EXHIBIT 1

EXHIBIT 67

UW Medicine
DEPARTMENT OF OPHTHALMOLOGY

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May 1, 2018

Neil Pederson, Esquire
Nichols Kaster PLLP
4600 IDS Center, 80 S. 8th St.
Minneapolis, MN 55402

RE: Quinton Harris et al. v. Union Pacific Railroad Company

Dear Mr. Pederson,

I have been retained to provide my opinions in the above matter to address the appropriateness of Union Pacific's (UP) Fitness-for-Duty vision requirements and specifically to rebut claims that its policy is necessary to promote safety.

I am the E.K. Bishop Endowed professor in Ophthalmology at the University of Washington in Seattle. I have been a research scientist and an educator for 30+ years. I am an expert in all aspects of disorders of the eye and their effect on visual performance. I have been involved in making key scientific discoveries that have revolutionized the understanding of the basis of color vision deficiencies and refractive errors of the eye. Based on a clearer understanding of color vision defects, I have developed refined methods for assessing color vison deficiencies including the Richmond HRR 4th edition color vision test, which has been the most widely sold color vision test in the United States for years, and it is acclaimed as being the best plate-type test available for testing color vision. I have also developed the Neitz test of color vision and a genetic test for color vision. Because of my expertise, I am frequently called upon for advice with regard to occupational standards for vision capacities. My research group also developed a gene-therapy cure for color blindness and spectacle lenses that prevent the development of nearsightedness in children.

I have reviewed how Union Pacific determined vision fitness-for-duty (FFD) testing in regards to the following seven (7) employees: Blaine D Kegarise, A.D. Pruitt, Brent MacDonald, Gaylon Cromeens, Leonard Barkmeier, Jeffery T Cooley and Dennis Naatjes.

Before reviewing the actual cases, however, please find a review of the occupational requirements and policies that UP would and should have used to determine FFD. Please also find enclosed the Code of Federal Regulations and the Federal Railroad Administration's interpretation as a separate document.

In preparation of my report, I have reviewed the following materials that you provided to me, including:

1. Union Pacific Railroad Health & Medical Services- Color Vision Field Test Form 16950
2. Image of a Color Vision Light Canon
3. A report from Dr. Holland
4. Medical records for the seven employee's listed above

Occupational Requirements for Vision

As with so many aspects of the human condition, there is an extremely wide range of visual capacity. For example, normal distance visual acuity is said to be "20/20". The phrase refers to how well a person can see on an eye chart devised in the 1800's by Dutch ophthalmologist Herman Snellen. Visual acuity of 20/20 is an arbitrary standard of what size letter most people, who do not need glasses, can see from a distance of 20 feet. Some adults can read the eye chart with 20/15 and 20/10 visual acuities, meaning that they can see letters on an eye chart at 20 feet away as compared to a person with 20/20 vision who needs to move up to 15 and 10 feet, respectively, in order to see. If a railroad required 20/10 vision in order to qualify as an engineer or conductor, this arbitrary standard would unfairly withhold opportunities from many people while doing nothing to protect the safety of the public. The question then becomes what are the correct standards that protect public safety but do not unfairly discriminate against employees?

Color Vision and the Federal Railroad Administrations Rules

The Code of Federal Regulations (CFR), Federal Railroad Administration (FRA), Qualifications and Certification of locomotive engineers has ruled regarding color vision that an individual must have the ability to recognize and distinguish between the colors of railroad signals as demonstrated by successfully completing one of the tests listed in the table below.

Accepted tests	Failure criteria
PSEUDOISOCHROMATIC PLATE TESTS	
American Optical Company 1965	5 or more errors on plates 1-15.
AOC - Hardy-Rand-Ritter plates - second edition	Any error on plates 1-6 (plates 1-4 are for demonstration - test plate 1 is actually plate 5 in book)
Dvorine - Second edition	3 or more errors on plates 1-15
Ishihara (14 plate)	2 or more errors on plates 1-11.
Ishihara (16 plate)	2 or more errors on plates 1-8.
Ishihara (24 plate)	3 or more errors on plates 1-15.
Ishihara (38 plate)	4 or more errors on plates 1-21.
Richmond Plates 1983	5 or more errors on plates 1-15.
MULTIFUNCTION VISION TESTER	

Keystone Otoscope	Any error.
OPTEC 2000	Any error.
Titmus Vision Tester	Any error.
Titmus II Vision Tester	Any error.

The FRA's locomotive engineer and conductor qualification and certification rules do not require railroads to categorically disqualify or decertify individuals who do not meet the vision thresholds because they may have a color-vision deficiency if they are otherwise qualified. To the contrary, railroads are required to subject, upon request, persons who do not meet those thresholds to further medical evaluation by the railroad's medical examiner to determine whether the person can safely perform work as a locomotive engineer or conductor. The FRA's longstanding view is that there are some people who, despite not meeting the vision threshold, have sufficient residual visual capacity to safely perform as a locomotive engineer or conductor. (CFR 240.121 - Criteria for vision and hearing acuity data; Federal Register / Vol. 80, No. 226 / Tuesday, November 24, 2015 / Rules and Regulations).

The FRA expects the railroad to offer a scientific test to further evaluate persons who fail an initial color vision test. Further testing must be valid, reliable and reproducible for assessing whether the person can safely perform duties as a locomotive engineer or conductor despite not seemingly meeting the specific vision threshold for color perception. The railroad must be able to cite a rigorous scientific study published in a peer-reviewed scientific or medical publication that demonstrates the scientific test is a valid, reliable and a comparable test for visual capacity.

Visual Acuity, Visual Fields and Binocularity and the Federal Railroad Administrations Rules
Distant visual acuity is required of at least 20/40 ***in each eye*** with or without corrective lenses or distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses; a field of vision of at least 70 degrees in the horizontal meridian in each eye must be present.

The FRA's locomotive engineer and conductor qualification and certification rules do not require railroads to categorically disqualify or decertify individuals who do not meet the vision because of deficiencies in visual acuity, visual fields and binocularity if they are otherwise qualified. Railroads are required to subject, upon request, persons who do not meet those thresholds to further medical evaluation by the railroad's medical examiner to determine whether the person can safely perform as a locomotive engineer or conductor.

Need for Color Vision Requirements for Engineers and Conductors
In some railroad wayside signal systems, signal color and signal orientation are redundant. The question has been asked if engineers and conductors with color vision deficiency can pass a Field Test because the signals are positional. It has been reported that when viewing redundant signals, railroad employees with defective color vision have a higher relative error risk than employees with normal color vision *(Reference: Railroad signal color and orientation: effects of color blindness and criteria for color vision field tests TG Raslear, J Multer - 2015 - rosap.ntl.bts.gov).*

There is no doubt that redundant signals reduce the demand on color vision capacity and the combination of color and positional cues can be sufficient for an engineer or conductor to

operate safely even if they do not have normal color vision. The fact that 20/10 visual acuity is not required to operate safely is analogous.

Occupational Testing for Color Vision Deficiency

Until the year 2000, the biological mechanisms responsible for congenital colorblindness were poorly understood. In 1986, the first cloning and sequencing of the genes for the human long (L) wavelength, middle (M) wavelength and short (S) wavelength cone visual pigments began a revolution of our understanding of colorblindness.

The three types of cones are sometimes called red, green and blue, but the more formal scientific abbreviations L, M and S cones will be used. Although it took over a decade for details to emerge, molecular genetics assisted in understanding colorblindness by the year 2000.

The vast majority of color vison tests in current use were invented before congenital color blindness was well understood. Many controversial and contrary ideas about colorblindness played a role in the design of color vison tests and often the tests reflected particular biases in the ideas of etiology of color vision. The result has been that many of the tests currently in use are not very effective. A few tests, however, stand out as better than the rest:

- Ishihara's test for colour deficiency 38 plates edition
- Richmond HHR 4th edition
- The Farnsworth D15 test
- The Nagel anomaloscope
- The Farnsworth Lantern (FALANT)/ OPTEC 900

Published papers describe the evaluations of the validity of each of the above tests in greater detail.

Although a few tests have been invented more recently, one particularly salient example is the Railway LED Lantern Test (RLLT) which is based on a simulated practical test that was developed by the University of New South Wales for RailCorp following the publication of the National Standard for Health Assessment of Rail Safety Workers (2004).

The most significant problem of occupational testing for vision problems is, by far, for people with congenital red-green color deficiency because of the extremely high prevalence of this particular set of disorders. Roughly one out of 12 men and one out of 220 women in the United States has some form of congenital red-green color deficiency.

Relatively good screening procedures have been designed to differentiate people with normal color vision from those with color vision deficiency. When properly administered to educated adults of normal intelligence by a trained practitioner, the **Ishihara has sensitivity of very close to 1**; more than 90% of men will pass and less than 10% will fail. **However, among the men who fail, there is a wide range of color discrimination ability.**

At one end of the range, making up roughly a third of the failed group, are the dichromats, individuals with the very worst form of congenital red-green color defect. They have almost no sensation of either red or green. They cannot distinguish a certain perfect red and a certain perfect green from white or gray. They are unable to distinguish certain colors of pure red from pure green. All the colors in the spectrum between yellow-green and red-orange appear indistinguishable and all the colors between violet and blue are indistinguishable.

Two-thirds of people who fail the Ishihara are anomalous trichromats. All anomalous trichromats have better red-green color vision than dichromats. Even the most severe anomalous trichromat has red-green color vision that is ten times better than a dichromat.

All trichromats experience sensations of red and green, can distinguish saturated reds and greens from white or gray and are able to differentiate pure red from green and from yellow. About half of all anomalous trichromats have minimal or mild color vision deficiency. Their color vision is closer to normal than dichromatic.

There is little question that such people can perform the visual tasks demanded by the transportation industry.

Finally, a group exists whose red-green color vision is intermediate between normal and dichromatic. Their red-green color vision may be ten times worse than normal but also ten times better than dichromatic.

The challenge, then, is to differentiate among people who fail the Ishihara; those who are able to make the required color discriminations from those who are not able. Attempts to separate these groups risk failures of two types. If the criteria are too lax, dichromats or extremely anomalous trichromats who are not safe to carry out the duties of the job are allowed employment.

If the criteria are too strict, capable people will be denied employment. **If employment decisions were made strictly on the basis of the Ishihara, about 4% of all males seeking jobs would be denied even though they are visually capable.**

The following tests all have some capability to differentiate people with minimal to medium color vision deficiency from those with severe color vision deficiency, where the former group would be able to interpret industrial color codes safely while the latter group would be unsafe.

The Nagel anomaloscope—this is the most precise test and it is considered to be the **gold standard.** It can be used to differentiate people with "medium" from those with "severe" color vision deficiency with nearly 100% accuracy. However, the anomaloscope is not practical, not widely available and it is expensive. The most prohibitive aspect is that to be used properly, it requires a highly trained expert operator.

Richmond HHR 4th edition—the main limitation of this test is that nearly a third of all dichromats are classified as "medium" using this test. The reason for this failure of the test is inherent to the nature of the underlying biology of color blindness. However, there are three levels within the medium category and more dichromats can be excluded by setting a more stringent criteria for passing within the medium category. A strength of the HRR is that it also tests for the more rare blue-yellow color vision deficiency in addition to red-green defects; however, a limitation is that it is possible to cheat on the HRR by memorizing the book. This problem can be avoided simply by altering the order of the pages in the test book. The test also has lighting requirements, but it is fairly robust to small deviations from the ideal lighting.

The Farnsworth D15 test— this test was designed to separate people into two groups. Thus, the "D" stands for "dichotomous." The first group includes people with normal color vision and slight color deficiency and the second group consists of people with moderate and severe color defects.

The limitations of this test are as follows:

- Five percent of men fail compared to 8% of red green color vision defects
- When compared to the anomaloscope, the D15 has an error rate of 1.5-6 % in correctly failing dichromats depending on the failure criterion
- More than 20% of severe anomalous trichromats pass. If this test is used on its own, there may be unacceptable numbers of people who are unfairly excluded from employment as well as too many people with severe color vision defects passing.
- Lighting requirements that are more stringent than the Ishihara or HRR.

An advantage of test, however, is that it is not possible to cheat on this test and it tests for both blue-yellow and red-green deficiencies.

The Farnsworth Lantern (FALANT)/ OPTEC 900—lanterns are vocational tests which are designed to simulate practical signal recognition used in the transportation industry. Like the D15, the Farnsworth lantern is designed to separate people into two categories-- those who are qualified by virtue of the ability to interpret industrial color codes safely from those who would be unsafe.

Like the D15 test, a substantial number of color deficient people pass the test with no guarantee that dichromats will always fail. Like the HRR, the failures in identifying dichromats are inherent to the design of the test and features of the biology of human color vision. **The Farnsworth lantern is no longer being manufactured; however, the OPTEC 900 was designed to be used as a replacement.**

The manufacturer's description states that the Optec® 900 color perception test was built as a modern version of the Farnsworth Lantern Test, which was used to assess color vision in aviation eye exams and other industries that require recognition of signal lights. Since the Farnsworth Lantern Test is no longer manufactured, its successor, the Optec® 900, is the preferred color vision test; it is more stringent and reduces risk of passing those who might make errors with signal lights.

These instruments are expensive and not widely available. When used on its own, there may be unacceptable numbers of people who are unfairly excluded from employment as well as too many people with severe color vision defects passing.

Recommendations

A **test battery composed of different tests** that offset the limitations of the tests used individually should be considered. A panel of tests consisting of the **Ishihara, HRR and D15** could be designed to minimize errors in both employing individuals who would be unsafe and denying work to color deficient people who are qualified.

An initial screening with the Ishihara could separate normal from color deficient people. Individuals who fail the initial screening would be subject to further tests with the HRR and D15. Very strict testing protocols would be required, including use of the proper lighting; randomization of testing materials to prevent gaming the test; and the use of a scoring algorithm. The constellation of results from the three tests would then be used to determine if an individual passed or failed.

The practical field tests do NOT offer any real advantages over a clinical test battery. It is very difficult to make a field test reliable, as there can be too many errors both in denying capable people employment and in hiring people who are not safe. Congenital color vision

defects are so stereotyped that a proper diagnosis using validated clinical tests can be highly predictive of vision capacities in the field.

Color vision tests included in vision screener devices have the advantage of being efficient, since color vision testing in integrated with other vision tests and there are no lighting requirements. The disadvantage is that there are very limited number of plates (Titmus and Keystone) they are very easy to cheat on.

a) **Titmus** contains images of six plates from the Ishihara, only four of which actually test for color vision deficiency. A control plate can be seen by everyone and the other, a hidden digit plate, is not efficient at distinguishing normal from color deficient vision. This test is sensitive and would rarely pass a color deficient person using the criteria of a perfect score on four diagnostic plates.
b) **Optec** (discussed above)

A Modern Evaluation of Federal Railroad Administrations Rules for Color Vision Appendix F
The FRA outlines a list of 12 (detailed above) acceptable tests and failure criteria which supposedly constitutes the demonstration of the ability to recognize and distinguish between the colors of railroad signals. The criteria are extremely stringent.

For example, the Ishihara (38 plate), criteria for failing is four or more errors on plates 1-21. The 38 plate Ishihara is wildly available and commonly used as a bench mark in screening for congenital red-green color vision deficiencies. According to the manual that is included with the Ishihara test book, the official directions for scoring the exam states for plates 1-21, "If only 13 or less than 13 plates are read normal the colour vision is regarded as deficient." According to the official manual, a total of eight plates have to be read incorrectly for color vision to be regarded as deficient. However, the FRA has arbitrarily set a standard that 4 errors constitute failing the test. This is much more stringent than the manufacturer has specified and it has been shown in scientific evaluations of the Ishihara that it is not uncommon for people with proven normal color vision to make 4-6 errors on the test, thus, failing the criteria set by the FRA. The entire list of acceptable tests and failure criteria have utilized similarly unreasonably stringent standards.

The FRA rules fail to recognize that color vision deficiency is not one thing. The failure criteria recommended by the FRA divides people into two groups, one labeled "color vision deficient" and a second labeled as having normal color vision. However, the "color vision deficient" group is extremely diverse it includes people who have normal color vision and majority of the people in that group that fail the FRA criteria clearly have the ability to recognize and distinguish between railroad signals.

By setting such a stringent criterion, the test will have a high false positive rate and many people who fail the test under these criteria actually have normal color vision. The Ishihara is an extremely sensitive test and using the FRA criteria will almost certainly identify all of the approximately 8% of men with red-green color vision deficiencies; however, as discussed above, about two-thirds of people who fail the Ishihara are anomalous trichromats. As outlined above, **there is no question that many anomalous trichromats can perform the visual tasks required to work on the railroad.**

People with minimal or mild color vision deficiency only have trouble with desaturated, subtle or pastel shades of color. The colors used in railroad signals are highly saturated primary colors, red, green and yellow which anomalous trichromats have no trouble distinguishing. The color

information added to the positional information makes for very salient differences in the signals that are easily distinguished. Arbitrarily rejecting anomalous trichromats that have minimal or mild color vision deficiency, unfairly withholds opportunities from many people while doing nothing to protect the safety of the public. Indeed, arbitrarily rejecting people with normal color vision who do not meet the overly stringent vision thresholds detailed above also unfairly withholds opportunities from people while doing nothing to protect the safety of the public

The following is a quote from:
Code of Federal Regulations VISION
Title 49 – Transportation Volume: 4
Title: Section Â§ 240.121 - Criteria for vision and hearing acuity data.

"FRA states in its locomotive engineer and conductor certification rules that, should a person not meet specific vision thresholds, appropriate further evaluation may include optometric or ophthalmologic referral, or (secondary) testing with a field or other practical or scientific screening test. Although FRA's rules grant discretion to railroads in selecting a test protocol, FRA's longstanding interpretation of this provision is *that the test offered by a railroad must be a valid, reliable, and comparable test for assessing whether a person who fails an initial vision test can safely perform as a locomotive engineer or conductor*. [emphasis added]"

According to the failure criteria (shown above) from the Code of Federal Regulations (CFR), Federal Railroad Administration (FRA), a number of individuals will not meet "specific vision thresholds" by failing to successfully complete one of the tests. There can be no doubt that the majority of those individual can perform the visual tasks required to work on the railroad.

Individuals who do not meet a "specific vision threshold" may be offered "the Color Vision Field Test" called the "Light Canon." The standard for vision testing is that in order to be considered to be a valid, reliable, and comparable test it must have been the subject of a rigorous scientific study published in a peer-reviewed scientific or medical publication. The CV Light Cannon has not been validated in this way. This validation is especially important in the case of the railroad because their initial screening criteria set by the Code of Federal Regulations, Federal Railroad Administration Qualifications and Certification of locomotive engineers is so stringent that the majority of individuals who do not meet the specific vision thresholds are perfectly able to perform the visual tasks required to work on the railroad.

The problem of designing an appropriate task-specific field test to establish the color vision requirements of a job is a very complex one with many pitfalls. In the absence of published scientific data that has been subject to peer review establishing its validity, the probability that an *ad hoc* test such as the Light Cannon could be a valid representation of what rail workers experience on the job is so low that we must assume it to be invalid. This is especially true since the testing procedures established by the railroad do not indicate a good understanding of the nature of color vision deficiency or the visual capabilities of those affected by it.

The federal aviation administration uses a protocol where scientifically validated clinical tests are used in screening exams to identify individuals who are dichromats or extremely anomalous trichromats,. Applicants who fail the color vision screening test, but desire an airman medical certificate without the color vision limitation, may be given, upon request, an opportunity to take and pass additional operational color perception tests. Similarly, a valid and fair approach would be to use scientifically validated clinical tests to identify severe anomalous trichromats and dichromats, rather than use an unvalidated, light canon test, on a group of people in which we

know that many are either normal or anomalous trichromats who are capable of performing tasks required of conductors and engineers.

Opinions of Specific Cases

Blaine D Kegarise Employee ID 0402899 Conductor

The physician statement on disability letter noted "disabled" only because he does not meet railroad vision standards for color vision or (depth?) perception. He was given a "color vision field test" and he, "Did very good-but last signal reported white/red."

Impression: Results in the file on a "color vision field test form" shows that the person identified 9 out of 10 signals correctly, making only one error. Tester's opinion: "Did very good-but last signal reported white/red." Presumably, from reading the test form, the signal was actually green/red not white/red.

Since his color vision was rated on the field test as "very good," it would appear that the color information added to the positional information of railroad signals would make them easily distinguishable by this individual. The CV Light Cannon field test does not conform to the criteria of having been subject to a rigorous scientific study published in a peer-reviewed scientific or medical publication. This fails to meet recommendation that the test should be a "valid, reliable and comparable test" for assessing whether the person can safely perform as a locomotive engineer or conductor despite not meeting the specific vision threshold for color perception.

Conclusion: **Mr. Kegarise was able to safely distinguish colors necessary for work as a conductor.**

A.D. Pruitt Employee ID 0130399 Engineer

This patient was diagnosed with bilateral proliferative retinopathy. An examination in 2016 revealed best corrected visual acuity in the right eye of 20/70 and the left eye 20/40. Lucentis injections and laser therapy may improve central vision.

Impression: This person meets the FRA guideline for one eye-- that person should have distant visual acuity of at least 20/40 in each eye without or without corrective lenses. The other eye may improve with treatment. With appropriate monitoring, consistent with the FRA's longstanding view, this is a person who, despite not meeting the vision threshold, has sufficient residual visual capacity to safely perform as a locomotive engineer or conductor.

Conclusion: **Mr. Pruitt has sufficient residual visual capacity to safely perform as a locomotive engineer.**

Brent MacDonald Employee ID 0409597 Conductor/ Trainman

Patient has a diagnosis of bilateral keratoconus. An ophthalmologist wrote an opinion that the condition was stable and there was not a risk of sudden visual incapacitation. Best corrected visual acuity was 20/25 in the right eye and 20/30 in the left eye.

Impression and Conclusion: **This person meets the FRA guidelines and is qualified to safely perform as a locomotive conductor/trainman**

Gaylon Cromeens

Patient says he has had lifelong vision issues associated with his premature birth. A letter from an ophthalmologist states that he was successfully treated for cataracts bilaterally and his visual acuity is 20/20 in his left eye; however, he has a scotoma in his right eye that limits his central vision. He evidently has peripheral vision from both eyes.

Impression: The FRA guideline states that a person should have distant visual acuity of at least 20/40 in each eye without or without correction. This person does not meet that criteria because of a small blind spot in his right eye. However, this is an unusual case and the people who wrote the rules were not considering the effects of a small scotoma. Consistent with the FRA's longstanding view, there are some people who, despite not meeting the vision threshold, have sufficient residual visual capacity to safely perform duties as a locomotive engineer or conductor.

Conclusion: **This person would qualify because he has good, well-corrected vision in both eyes with a good field of view and only suffers from a scotoma in one eye.**

Leonard Barkmeier Conductor/Engineer
He is a 52-year-old male patient with high blood pressure and type II diabetes. On his vision exam, he has visual acuity of 20/20 in both eyes with corrective lenses. His visual fields were normal. He was diagnosed as having abnormal color vision based on testing with the Ishihara. The examiner's impression was that he had an acquired color vision deficiency. However, when treated with red filters over his glasses, he was able to read 14 out of 14 plates without error. In the patient's records, there are some results from the Farnsworth D-15 Dichotomous Color Blindness Test; however, the results are difficult to read. It is **not** evident that he failed the D15 and nowhere in his records does it indicate that he did.

Impression: The patient has good vision in both eyes. It is highly unlikely that the employee has a diagnosis of acquired color vison deficiency since red-green color vision deficiencies are seldom acquired and when they are, they are usually associated with other vision abnormalities which were not present in this case. Given the facts of his case, a diagnosis of congenital red-green color vision *deficiency* is more likely. Of people who make errors on the Ishihara as this patient did, most have a mild to medium deficiency and they have no trouble distinguishing the saturated primary colors such as those used in railroad signals.

The Farnsworth D15 test administered to this patient was designed to separate people into two groups. There is no indication that the results from the D15 placed this individual in the category of having a color vision defect that would disqualify him from work as a conductor/engineer.

Conclusion: **The available medical evidence does NOT suggest that Mr. Barkmeier cannot safely distinguish colors necessary for work as a conductor/engineer; there is no reason he could not and still cannot perform the job.**

Jeffery T Cooley Conductor
On a vision exam, the patient had corrected visual acuity of 20/20 in each eye tested individually and 20/15 using both eyes. His peripheral vision was normal. He made errors on a 14 plate Ishihara test consistent with congenital red-green color vision deficiency. In the patient's records, there are results from administration of the Farnsworth D15 on which this **patient received a perfect score**. The Union Pacific color vision field test was also administered to this patient and he correctly identified 8 out of 10 signals.

Impression: The patient has very good vision in both eyes. He made errors on the Ishihara test,

however, most people who make errors on the Ishihara have a mild to medium deficiency and they have no trouble distinguishing the saturated primary colors such as those used in railroad signals.

The patient's Ishihara results taken together with D-15 indicate that he has a *slight congenital red-green color vision deficiency*. Such individuals do not have difficulty distinguishing saturated primary colors like those used in railroad signals. The patient did make two errors out of 10 on the color vision field test. However, there is no evidence published in a peer reviewed journal that this CV Light Cannon field test conforms to the FRA recommendation that the test should be a "valid, reliable and comparable test" for assessing whether the person could safely perform as a locomotive engineer or conductor despite not meeting the specific vision threshold for color perception.

Conclusion: **Mr. Cooley was able to safely distinguish colors necessary for work as a conductor.**

Dennis Naatjes Conductor
Patient's eye exam shows corrected visual acuity of 20/20 and 20/15 in his left and right eye, respectively. His record shows that his color vison was tested with the Ishihara/D15 and that he had 19 out of 20 correct in each eye tested individually. He was diagnosed as having an unspecified color vision deficiency. The examiner's impression was "very mild red-green color vison deficiency good result."

Impression: **The patient has very good corrected vison and was diagnosed as having a "very mild red-green color vision deficiency."**

Conclusion: **Mr. Naatjes has been, and presumably is still, able to safely distinguish colors necessary for work as a Conductor.**

SUMMARY:
The Federal Railroad Administration (FRA) locomotive engineer and conductor qualification and certification rules do have specific guidelines that need to be addressed, however the FRA does not require railroads to categorically disqualify or decertify individuals who do not meet the vision thresholds because they may have a color-vision deficiency or acuity discrepancy if they are otherwise qualified.

For persons who do not meet those thresholds, railroads are required, as requested, to further offer medical evaluation by the railroad's medical examiner to determine whether the person can safely perform work as a locomotive engineer or conductor. The FRA longstanding view is that there are some people who, **despite not meeting the vision threshold, have sufficient residual visual capacity to safely perform as a locomotive engineer or conductor.**

The FRA expects the railroad to offer a scientific test to further evaluate persons who fail an initial color vision test or have an acuity anomaly. **Further testing must be valid, reliable and reproducible for assessing whether the person can safely perform duties as a locomotive engineer or conductor despite not seemingly meeting the specific vision threshold**. There is no rigorous scientific study published in a peer-reviewed scientific or medical publication that demonstrates the CV Light Cannon is a valid, reliable and a comparable test for visual capacity.

In all the above instances, UP did not seemingly offer a reasonable, scientific based reliable and comparable test to determine if accommodation was possible and reasonable. As illustrated in the above examples, had such reasonable accommodation been pursued with the appropriate medical expertise and support, accommodation and continued employment would have ensued.

I reserve the right to add to, change, and/or modify my report should additional information become available to me. My consulting fees, including for deposition and/or trial are $200.00 per hour.

In 2014, I was asked for my expert opinion with regard to color vision for the plaintiff in the case, DAVID A. CURRY vs. THE DOCTORS CLINIC. I was deposed and gave testimony in the arbitration hearing.

I have attached a copy of my curriculum vitae and a list of my publications.

Sincerely,

Jay Neitz, Ph.D.

List of Documents consulted

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Union Pacific Railroad
1400 Douglas Street- STOP 0350
Omaha, NE 68179

Health & Medical Services- Color Vision Field Test Form
Form 16950
Rev 07/2015

Date:

To:

From: XXXXXXXXXXXXX for Union Pacific Railroad- Chief Medical Officer

Subject: Schedule Request- Color Vision Field Test

Regarding:

Employee ID #:

Job Title:

Please do the following:

1. Notify the employee and schedule the Color Vision Field Test. The field test MUST be completed within 14 days of receipt of this request.
2. Please review the attached procedure on conducting a Color Vision Field Test and print the required forms to complete the exam testing.
3. Submit the completed Color Vision Field Test Forms immediately following the Color Vision Field Test to Health & Medical Services by the barcode fax sheet to the confidential fax line at (402) 501-0067 OR upload the completed test forms to eHealthSafe- Applicable Medical Documents.

Executive Summary

This document contains all instructions necessary to complete a controlled Color Vision Field Test {CVFT). It is necessary to ensure compliance with all guidelines for a consistent, valid CVFT. Each CVFT will consist of 20 trials of a "Light Cannon." Failure to recognize one signal color during CVFT will constitute a failure. This will meet the threshold determined in the "Railroad Signal Color and Orientation: Effects of Color Blindness and Criteria for Color Vision Field Tests" for a color-only CVFT. The CVFT will be considered a medical test therefore requiring participation of an Occupational Health Nurse (OHN).

Summary of Duties

In order to improve reliability, strict control for the color-only Color Vision Field Test requires the following employees to be present:

- Manager 1
- Manager 2
- OHN

Their responsibilities are as follows:

Manager 1

- Calibrates "Light Cannon"
- Obtains color order from Color Vision Field Test Form
- "Sight In" "Light Cannon"
- Communicates with Manager 2 to proceed through the CVFT
- Toggles "Light Cannon" color for each signal
- Signs Color Vision Field Test Form
- Stores "Light Cannon"

Manager 2

- Calibrates "Light Cannon"
- Obtains and retains CVFT Instructions and Employee Acknowledgment form.
- Communicates next signal to Manager 1 via UPRR provided cell phone during CVFT
- Signs Color Vision Field Test Form
- Escorts employee and Union Representative to designated waiting area

OHN

- Calibrates "Light Cannon"
- Records Employee Responses on Color Vision Field Test Form
- Signs Color Vision Field Test Form
- Faxes Color Vision Field Test Forms to Health and Medical Services confidential fax line at (402) 501-0067. Alternatively, the OHN can go to eHealthSafe and upload to "Applicable Medical Documents."

Note: Union Representation should be present for observation only at Employee's request.

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Manager Instructions

Managers will receive Color Vision Field Test Form from Health and Medical Services (HMS) prior to administration of the test. The CVFT packet will consist of the Letter of Referral, Color Vision Field Test Form, Employee Instructions and Acknowledgement from, the Manager Color Order Sheet, the Color Vision Field Test Calibration form and the standard work documentation for administration of CVFT. The Manager Color Order Sheet will be given to Manager 1and be the same sequence listed on Color Vision Field Test Form. The following items should be completed in the order below.

Administrator Coordination

In order to conduct the test in the same manner each time, Manager 1, Manager 2, and OHN must perform a job briefing between of each other that consists of:

- Safety Briefing
- Color Order Discussion (Color Vision Field Test Form)
- Role Communication (Standard Work)

light Cannon Calibration Procedure

To calibrate the "Light Cannon," each color must be tested individually and a calibration form must be filled out at the site where the lights will be illuminated. To calibrate, verify that the correct color is presented when pressing each color toggle. Record the length of time each color is presented by a watch with a second hand. Calibration should be completed in the following order:

1. Press main power toggle switch.
2. Press Red toggle and record length of illumination
3. Press Green toggle and record length of illumination
4. Press Yellow toggle and record length of illumination
5. Press Lunar/White toggle and record length of illumination

If illumination time is not approximately 5 seconds, test should be rescheduled and "light cannon" should receive maintenance. Both Manager 1and Manager 2 should record the length of time for which each color presents.

Employee Instructions and Acknowledgement

The employee should be given the following instructions verbatim:

a. "If you normally wear any visual correction, you are required to wear your normal glasses or contacts."

b. "You are not allowed to wear any corrective color vision contact lenses (chromatic/chromagen/tinted lenses)."

c. "For the Color Vision Field Test you will be shown a total of 20 color signals."

d. "When each signal is presented name the color (In English) of the signal as red, green, yellow or lunar/white."

e. "Call out the colors as presented, even if this does not represent a signal used in your work area. This is to test the ability to correctly identify colors and not of knowledge of what signals mean."

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f. "Each signal will be presented for 5 seconds and turned off. There will be a short pause and then we will call for the next signal to be presented."

g. "Your first answer is final. No change in response is allowed."

h. "You will not be told if your responses were correct or incorrect until after the test is done."

i. "Do you understand these instructions and do you have any questions?"

Once these statements are read, the Union Representative and Employee will be asked to acknowledge these statements being correctly made in the Employee Acknowledgement sheet. Any employee questions, comments, or concerns should be documented on the Employee Acknowledgement sheet at this time. Do NOT proceed until Employee Instructions and Acknowledgement is signed. Refusal on the part of the employee will constitute failure. The OHN, Manager 2, employee, and Union Representative, should then proceed from the waiting area to the testing point as predetermined.

Perform Test

Each person should be in the following positions:

- Manager 1 should be at the "Light Cannon" with the color order ready to administer CVFT. Before beginning the test, manager 1 should "Sight In" the "Light Cannon."
- Manager 2 should be 5 feet or more behind the Employee and OHN but in normal hearing range of OHN to call for next signals via UPRR compliant company cell phone.
- OHN should be just off the shoulder of the employee not obstructing his/her view.
- Union Representative should be standing next to Manager 2.

Once prior procedures are completed, the OHN should acknowledge the following on the Color Vision Field Test Form:

The test is performed:

- Between 10:00 and 14:00
- At X mile from the "Light Cannon"

Once this information is recorded, the test can be administered. Here are the steps for the CVFT test administration:

1. Employee gives the "ready" signal to OHN.
2. OHN will tell manager 2 to begin the test.
3. Manager 2 will radio Manager 1 to toggle first color signal.
4. During signal illumination, employee is required to respond with a color.
    a. The first color verbalized is the color of record. Any subsequent color for a given signal should be ignored.
5. OHN should record if the signal was identified correctly.
    a. If not, OHN will record incorrect response in the manager comments section.
6. Once result is recorded, Manager 2 will verbalize to Manager 1 to toggle the next color via UPRR compliant company cell phone.

The following MUST be followed for validity of CVFT:

- All 20 signal colors should be shown in the order on the delivered Color Vision Field Test Form.

- Even if employee gives incorrect response, test is concluded through the end as if he/she completed the test will all signals correct.

- During the test, OHNs should **not** tell the employee whether or not a response was correct.
- The manager should write a note in the Comments section of the signature box if there are any irregularities in the test.

Test Completion

When test is complete,

- Manager 1, Manager 2, and OHN should each sign the CVFT Scoring Form.
- The OHN should fax or upload the completed CVFT Scoring Form, employee acknowledgement sheet, and calibration sheet to HMS and confirm these are received.
- DO NOT give copies of Color Vision Field Test Form to the employee.
- If test is not completed, record why and continue to fill out applicable fields on the Color Vision Field Test Form.
- Manager 1 is responsible for storage of the "Light Cannon."
- Manager 2 should escort Employee and Union Representative to designated waiting area.

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Health & Medical Services- Color Vision Field Test Calibration Form

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Light Cannon Serial Number

Signal Color	Length of Illumination Time Manager1	Length of Illumination Time Manager 2
1. Red		
2. Green		
3. Yellow		
4. Lunar/White		

Managers Administering the Color Vision Field Test

1st Manager: Name_____
Signature.,---_____Date._____
Comments:

2"d Manager: Name_____
Signature.,---_____Date._____
Comments:

Nuffie:Name_____
Signature.,---_____Date._____
Comments:

UNION PACIFIC RAILROAD- HEALTH AND MEDICAL SERVICES (7/29/2015)

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Employee Instructions for Color Vision Field Test

Background

The employee is a Train Crew member who recently failed an Ishihara color vision test done for the employee's FRA Certification exam. The employee is now being given a Color Vision Field Test (CVFT) to determine if he/she could correctly identify colored train signals in a simulated field setting.

This page has instructions for the employee in conducting the CVFT and acknowledgement of such.

Read the employee the instructions for the CVFT noted below:

a. "If you normally wear any visual correction, you are required to wear your normal glasses or contacts."

b. "You are not allowed to wear any corrective color vision contact lenses (chromatic/chromagen/tinted lenses)."

c. "For the Color Vision Field Test you will be shown a total of 20 color signals."

d. "When each signal is presented name the color (In English) of the signal as red, green, yellow or lunar/white."

e. "Call out the colors as presented, even if this does not represent a signal used in your work area. This is to test the ability to correctly identify colors and not of knowledge of what signals mean."

f. "Each signal will be presented for 5 seconds and turned off. There will be a short pause and then we will call for the next signal to be presented."

g. "Your first answer is final. No change in response is allowed."

h. "You will not be told if your responses were correct or incorrect until after the test is done."

i. "Do you understand these instructions and do you have any questions?"

Employee Comments/Questions

Employee: Name_____ Title_____ Phone _____
Signature Date_____
Comments:

Union Rep.: Name_____ Title_____ Phone _____
Signature Date_____
Comments:

Health & Medical Services- Color Vision Field Test Form
Form 16950
REV 7/2015

Employee Name:	Employee ID:
Job Title:	Test Date:
D Time of Day (Local) between 10:00 and 14:00	D Distance% mile

Signal Color	Did employee identify the signal correctly? Circle YES or NO	Manager Comments (for incorrect responses record colors called)
1. Green	YES NO	
2. Yellow	YES NO	
3. Red	YES NO	
4. LunarNVhite	YES NO	
5. Red	YES NO	
6. Green	YES NO	
7. Red	YES NO	
8. Green	YES NO	
9. Yellow	YES NO	
10. Red	YES NO	
11. Green	YES NO	
12. LunarNVhite	YES NO	
13. Red	YES NO	
14. Green	YES NO	
15. LunarNVhite	YES NO	
16. Red	YES NO	
17. Red	YES NO	
18. Green	YES NO	
19. Yellow	YES NO	
20. Yellow	YES NO	

Health & Medical Services- Color Vision Field Test Form
Form 16950
REV 7/2015

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Health & Medical Services- Color Vision Field Test Form
Form 16950
REV 7/2015

By signing below, the following parties attest to accuracy and consistency of CVFT as described by guidelines in the CVFT Handbook.

Managers administering the Repeat Color Vision Field Test

Please make a note in the comment of any deviation from optimal testing or visual conditions.

2"d Manager: Name_____ Title_____ Phone _____
Signature Date_____
Comments:

Nurse: Name_____ Title_____ Phone _____
Signature Date_____
Comments:

By signing below, the following parties attest to consistency of CVFT as described by guidelines in the CVFT Handbook.

Please make a note in the comment of any deviation from optimal testing or visual conditions.

1[51] Manager: Name_____ Title_____ Phone _____
Signature Date._____
Comments:

UNION PACIFIC RAILROAD- HEALTH AND MEDICAL SERVICES (7/29/2015)

Health & Medical Services- Color Vision Field Test Form
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Manager Color Order Sheet

The following order should be used for this CVFT.

D 1. Green

D 2. Yellow

D 3. Red

D 4. LunarNVhite

D 5. Red

D 6. Green

D 7. Red

D 8. Green

D 9. Yellow

D 10. Red

D 11. Green

D 12. LunarNVhite

D 13. Red

D 14. Green

D 15. Lunar/White

D 16. Red

D 17. Red

D 18. Green

D 19. Yellow

D 20. Yellow

Health & Medical Services- Color Vision Field Test Form
Form 16950
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Job Instruction Breakdown Sheet - OHN		
Area: UP Safety/HMS	Job: CVFT Test Administration	Date: 07/27/2015 Written by: CVFT Test Team
Major Steps (What)	Keypoints (How)	Visual Cue (FiQures)
Include all major in-cycle steps Start-up or ancillary to be separate	Safety: Prevent HF Errors Due to Color Vision Deficiencies Quality: Provide a controlled test for measuring CVFT Technique: Special Method Requiring Attention Cost: Cost of Purchase and Maintenance of CV "Light Cannon"	Ask; Why do we do it that way? What would happen if we did it a different way?
Step 0. Receive CVFT Referral: Start Process	Receive CVFT Packet from HMS	To ensure proper employee CVFT is administered correctly.
Step 1. Test Administrator Job Breifing	1. Safety Briefing 2. Discuss "Light Cannon" Administrator Role (Manager 1) 3. Discuss Communicator Role (Manager 2) 4. Discuss Scorer Role (OHN) 5. Give Manager Color Order Sheet to Manager 1 6. Discuss Color Order	To communicate and confirm roles and procedures to be performed in test. This will require a coordinated effort between the test administration team members to meticulously administer test each time.
Step 2. "Light Cannon" Calibration	1. Witness Calibration performed by Manager 1 and Manager 2. 2. Sign Color Vision Field Test Calibration Form	To verify "Light Cannon" timing accuracy for constency among individuals taking the CVFT.
Step 3. Employee Acknowledgement	Where: Designated waling area. 1. Witness CVFT Employee Instructions and Acknowledgement and Safety Briefing with Employee performed by Manager 2. NOTE: Do NOT proceed until Employee Instructions and Acknowledgement is signed. Refusal on the part of the employee will constitute failure.	Communicate with employee to verify that rules and processes are understood. This avoids a potential point of invalidation of the test.
Step 4. CVFT Test	Where: Immediately behind and off of the shoulder of the employee so that te employee cannot see recorded results. 1. Ask employee "Are you ready?" 2. Ask Manager 2 "Are you ready?" 3. Once Manager 2 Verifies that Manager 1is ready by saying "Prepare for the test to begin" listen for employee response. 4. Ifthe employee responds when light is illuminated record. response. If incorrect, record the color that was indicated. 5. Wait approximately 5 seconds and repeat steps 1-4 until all 20 colors have been shown.	Score CVFT in a standard process.
Step 5. Manager Acknowledgement	1.Reconvene Test Administration Team. 2. Sign Color Vision Field Test Form.	This ensures quality of test by all parties administrating test.
Step Sa. Fax Documents to HMS	1. Place Color Vision Field Test Form, on Scanner Bed/Fax Machine. FaColor Vision Field Test Form, Employee Instructions and Acknowledgement, and Color Vision Field Test Calibration Form. 2. Fax document to confidential fax line (402) 501-0067. 3. Alternatively, upload documents to eHealthSafe -Applicable Medical Documents.	This allows HMS to make a determination to the eligibility of the employee.

Job Instruction Breakdown Sheet - Manager 1		
Area: UP Safety/HMS	Job: CVFT Test Administration	Date: 07/27/2015 Written by: CVFT Test Team
Major Steps (What)	Keypoints (How)	Visual Cue (Figures)
Include all major in-cycle steps Start-up or ancillary to be separate	Safety: Prevent HF Errors Due to Color Vision Deficiencies Quality: Provide a controlled test for measuring CVFT Technique: Special Method Requiring Attention Cost: Cost of Purchase and Maintenance of CV "Light Cannon"	Ask; Why do we do it that way? What would happen if we did it a different way?
Step 0. Receive CVFT Referral: Start Process	Receive CVFT Packet from HMS	To ensure proper employee CVFT is administered correctly.
Step 1. Test Administrator Job Breifing	1. Safety Briefing 2. Discuss "Light Cannon" Administrator Role (Manager 1) 3. Discuss Communicator Role (Manager 2) 4. Discuss Scorer Role (OHN) 5. Give Manager Color Order Sheet to Manager 1 6. Discuss Color Order	To communicate and confirm roles and procedures to be performed in test. This will require a coordinated effort between the test administration team members to meticulously administer test each time.
Step 2. "Light Cannon" Calibration	1. Press main power toggle switch. 2. Press Red toggle and record length of illumination. 3. Press Green toggle and record length of illumination. 4. Press Yellow toggle and record length of illumination. 5. Press Lunar/White toggle and record length of illumination. 6. Sign Color Vision Field Test Calibration Form. Note: At this time, leave power to "Light Cannon" on.	To verify "Light Cannon" timing accuracy for constency among individuals taking the CVFT.
Step 3. Employee Acknowledgement	Where: Designated waling area. 1. Witness Employee Acknowledgement and Safety Briefing with Employee performed by Manager 2. Note: Do NOT proceed until Employee Instructions and Acknowledgement is signed. Refusal on the part of the employee will constitute failure.	Communicate with employee to verify that rules and processes are understood. This avoids a potential point of invalidation of the test.
Step 4. CVFT Test	Where: At "Light Cannon" 1. "Sight In" "Light Cannon to align direction of signal with Employee. 2. Wait for Manager to Communicate via Radio that Employee is ready. 3. Verify readiness by saying "I am ready." 4. Wait approximately 3 seconds. 5. UseToggle Switch to illuminate light as seen on the Manager Color Order Sheet. 6. Mark that signal as complete by checking the box. 7. Repeat Steps 2-6 until all 20 colors have been shown.	Illuminate the signal colors in a distinct order with consistency between tests.
Step 5. Manager Acknowledgement	1. Reconvene Test Administration Team . 2. Sign Scoring Sheet and Comment as necessary.	This ensures quality of test by all parties administrating test.
Step 6c. Store "Light Cannon"	1. Toggle Power Switch Off. 2. Move "Light Cannon" to designated area in SU.	Store the "Light Cannon" consistently across the system to prevent potential calibration issues.

Job Instruction Breakdown Sheet - Manager 2

Area: UP Safety/HMS	Job: CVFT Test Administration	Date: 07/27/2015 Written by: CVFT Test Team
Major Steps (What)	Keypoints (How)	Visual Cue (Figures)
Include all major in-cycle steps Start-up or ancillary to be separate	Safety: Prevent HF Errors Due to Color Vision Deficiencies Quality: Provide a controlled test for measuring CVFT Technique: Special Method Requiring Attention Cost: Cost of Purchase and Maintenance of CV "Light Cannon"	Ask; Why do we do it that way? What would happen if we did it a different way?
Step 0. Receive CVFT Referral: Start Process	Receive CVFT Packet from HMS	To ensure proper employee CVFT is administered correctly
Step 1. Test Administrator Job Breifing	1. Safety Briefing. 2. Discuss "Light Cannon" Administrator Role (Manager 1). 3. Discuss Communicator Role (Manager 2). 4. Discuss Scorer Role (OHN). 5. Give Manager Color Order Sheet to Manager 1. 6. Discuss Color Order.	To communicate and confirm roles and procedures to be pe test. This will require a coordinated effort between the test administration team members to meticulously administer tes
Step 2. "Light Cannon" Calibration	1. Press main power toggle switch. 2. Press Red toggle and record length of illumination. 3. Press Green toggle and record length of illumination. 4. Press Yellow toggle and record length of illumination. 5. Press Lunar/White toggle and record length of illumination. 6. Sign Color Vision Field Test Calibration Form. Note: At this time, leave power to "Light Cannon" on.	To verify "Light Cannon" timing accuracy for constency amo individuals taking the CVFT.
Step 3. Employee Acknowledgement	Where: Designated waling area. 1. Safety Briefing. 2. Read Specified Instructions to Employee on Employee Acknowledgement sheet verbatim. 3. Record any Questions, Comments, or Concerns. 4. Employee and Union Representative Sign Employee Acknowledgement Sheet. Note: Do NOT proceed until Employee Instructions and Acknowledgement is signed. Refusal on the part of the employee will constitute failure.	Communicate with employee to verify that rules and proces understood. This avoids a potential point of invalidation of th
Step 4. CVFT Test	Where: At lease!5 feet behind OHN and Employee 1. Take the Union Representative at least 5 feet, but in normal hearing range of Employee and OHN. 2. Once OH N asks "Are you ready?", radio communicate with Manager 1 and ask "Are you ready?" 3. After Manager 1 Responds with "I am ready", say "Prepare for the test to begin." 4. Repeat steps 2-3 until all 20 colors have been shown. Note: No note taking is permitted.	Score CVFT in a standard process.
Step 5. Manager Acknowledgement	1. Reconvene Test Administration Team 2. Sign Scoring Sheet and Comment as necessary	This ensures quality of test by all parties administrating test

Step 6b. Escort Employee and Union Representative to Waiting Area/Work Area	1. Without mentioning test outcome, lead Employee and Union Representative to designated waiting/work area.	Consistency ensures one less point of failure for test valida

CURRICULUM VITAE

February 2018

Jay Neitz, PhD

ADDRESS And CONTACT INFORMATION

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EDUCATION	1976-1980	BA Physics San Jose State University
	1980-1986	PhD University of California, Santa Barbara
POST GRADUATE TRAINING	1986-1989	Post-Graduate Research Scientist University of California, Santa Barbara
PREVIOUS FACULTY APPOINTMENTS	1989-1991	Research Assistant Professor University of California, Santa Barbara
	1991-1995	Assistant Professor Department of Cellular Biology and Anatomy Medical College of Wisconsin
	1995-2000	Associate Professor Department of Cellular Biology and Anatomy Medical College of Wisconsin
	1997	Granted tenure
	2000-2008	Professor Department of Cellular Biology and Anatomy Medical College of Wisconsin
	2006-2008	Professor Department of Ophthalmology Medical College of Wisconsin

CURRENT FACULTY APPOINTMENTS	2009-	Professor Department of Ophthalmology University of Washington
	2009-	Adjunct Professor Department of Biological Structure University of Washington
ENDOWED PROFESSORSHIP	2009-	E. K. Bishop Professor of Ophthalmology, University of Washington
SOCIETY HONORS	2009	Fellow of the Optical Society of America
	2015	Fellow of the Association for Research in Vision and Ophthalmology (FARVO)
AWARDS	2002	**ALCON PRIZE** For excellence in vision research
	2009	Time Magazine top 10 scientific discoveries for 2009 (#3) Curing colorblindness in primates
	2010	**PEPOSE AWARD IN VISION SCIENCE** (Inaugural Recipient) from Brandeis University, Boston
	2009-2014	Our work has been featured in a three-part documentary entitled “Cracking the Colour Code” filmed by Electric Pictures in collaboration with the Australian Broadcast Corporation; in a BBC documentary on color vision entitled “Do you see what I see?”, and in “Your Inner Primate” the third episode of “Your Inner Fish” recently aired on PBS.
	2016-	**EDRIDGE-GREEN MEDAL AND LECTURE 2106** From The Royal College of Ophthalmologists

FUNDING

Current Funding

02/01/2018-01/31/2023	PHS 1R01EY027859 Linking retinal circuits to perception Principle Investigator, Current year direct costs $277,084
2016-2021	PHS P30 EY01730-41 Module Director, Maureen Neitz, Principal Investigator, current year direct costs $500,000 (Core Grant for Vision Research)

2014 – 2019	PHS EY023937 Co-investigator, Russel Van Gelder, Principle investigator Photoswitchable channel blockers for the treatment of blindness 1,454,487 (direct costs per year)
2017-2020	Tietze Family Foundation, University of Washington, $64,000/yr for 3 years, role of aberrant splicing of cone opsin genes in retinal disease, Co-Investigator, Maureen Neitz, Principal Investigator
2015-2019	M.J. Murdock Charitable Trust, J. Neitz PI $326,500 (total project cost paid by the Trust) Adaptive optics imaging

Submitted Applications

2018-2025	NEI R01EY028118 Co-investigator, Maureen Neitz, Principle investigator. Dual amino acid and splicing code in cone based vision disorders (5th percentile, anticipated start data April 2018)
2018-	REGENERON Sponsored research: Opsin Delivery to non-human primate eyes after intravitreal Gene Therapy. Total direct costs $505,928. Anticipated start date February 2018.
2018-2025	NEI R24EY027284-01A1 Co-investigator, Maureen Neitz Principle investigator. Cone Opsin gene therapy for XL-myopia, XL-COD and incomplete ACHM: translational research

PROFESSIONAL SOCIETY MEMBERSHIPS

Association for Research in Vision and Ophthalmology (ARVO)
Optical Society of America (OSA)
Alcon Research Institute (ARI)
International Colour Vision Society (ICVS)

OTHER PROFESSIONAL ACTIVITIES

Reviewer for Journals

American Journal of Human Genetics
Human Genetics
Journal of the Optical Society of America
Visual Neuroscience
Vision Research
Nature
FEBS letters
Investigative Ophthalmology and Visual Science
Journal of Experimental Biology
Science
PNAS

New England journal of Medicine
Current Biology
Journal of Neuroscience
PLOS ONE
Proceedings of the Royal Society B: Biological Sciences
Experimental Eye Research

Editorial Boards 2000 Feature Editor – Chromatic Topography of the Retina, *Journal of the Optical Society of America A*: *Optics, Image Science, and Vision.*

Reviewer for Granting Agencies National Science Foundation
The Wellcome TRUST, London, England
Ad hoc reviewer, NIH VISC study section
Ad hoc reviewer, NIH ZRG Special emphasis review group
Ad hoc reviewer, NIH DPVS study section

INVITED LECTURER (Recent)

INTERNATIONAL

EVER 2015 - Congress information. Nice, France, Oct 7-10
Keynote Lecture entitled "*Lessons learned from gene therapy for color blindness in primates*"

Keynote Speaker, September 25-27, 2015 Wenzhou, China, 15th Annual International Myopia Conference (The Paradox of myopia).

Royal College of Ophthalmologists Annual Congress 2016 Birmingham England, May 24 The Eldridge Green Lecture 2016 *"How the world became coloured"*

Symposium on "Seeing Colors", Sept. 19-21, 2016 University of Regensburg, Germany "Evolution of color vision in primates"

Colour in Mind - From Perception to Art 21.-23. September 2016 in Tübingen Germany

USA

Center for Neural Science NYU Nov 10 2014
"Lessons learned from gene therapy for colorblindness in primates"

ARVO 2015 Exploring the distribution and expression of L-, M- and S-cone photoreceptors – Minisymposium *"Explanatory power and predictions of a labeled line theory of color perception"*

Wabash College, Crawfordsville, IN, *Distinguished lecturer (November 3 – 6, 2015)*

UCLA Jules Stein Eye Institute Distinguished Lecture February 2017
"The evolution of color vision in primates and implications for curing color blindness with gene therapy."

American University *Center for Behavioral Neuroscience.* May 5, 2017
"The evolution of color vision in primates"

EXTRAMURAL INVITED LECTURER, COURSES

2014 Summer Workshop on the Dynamic Brain at Friday Harbor.

TEACHING

Teaching Awards

1999	Harry Beckman Basic Sciences Teaching Award for Teaching Excellence
2000	Outstanding Mentor Award from the Graduate Student Association
2001	Honorary Membership in Alpha Omega Alpha-Wisconsin Beta Chapter Medical Honor Society
2004	Outstanding Teacher Award from the Graduate Student Association
2005	Inducted into the Medical College of Wisconsin Society of Teaching Scholars

POSTDOCTORAL FELLOWS (co-mentored with Maureen Neitz)

1992-1994	David Miller, Ph.D., Brown University, Department of Psychology
1996-1998	Shawn Balding, Ph.D., Corneal Systems, CA
2002-2003	Joe Carroll, Ph.D., Associate professor of Ophthalmology, Medical College of Wisconsin
2002-2006	Karen Gunther, Ph.D., Associate Professor of Psychology, Wabash College
2005-2008	Michael Pauers, Ph.D., Lecturer in Zoology University of Wisconsin - Waukesha
2011-2015	Christian Puller PhD Carl von Ossietzky University, Dept. of Neuroscience Oldenburg, Germany
2011-2015	Mike Manookin, Assistant Professor of Ophthalmology University of Washington
2007-2010	Katherine Mancuso, PhD.
2008-	James A. Kuchenbecker PhD
2013-	Adam Crain

GRADUATE STUDENTS

PhD students **(co-mentored with Maureen Neitz)**

1992-1997	Stephanie Hagstrom, PhD, Senior Scientist, Cleveland Clinic
1993-1998	Pam Kainz PhD, Research scientist, Harvard

1995-1998	Stacy Sjoberg, MD,PhD, Adjunct appointment in Ophthalmology University of Minnesota
1998-2001	Kathryn Bollinger, MD, PhD, Associate Professor, Georgia Regents Medical Center Augusta, Georgia
1998-2002	Joe Carroll PhD, Professor, Ophthalmology, Medical College of Wisconsin
1998-2003	Carrie McMahon, PhD, Instructor, Milwaukee Area Technical College
2002-2007	Katie Mancuso, PhD
2004-2008	Jim Kuchenbecker, PhD Post-doc U. Washington
2004-2008	Diane Tait, PhD Assistant Professor University of Wisconsin Oshkosh
2005-2008	Matthew Mauck, MD, PhD. Assistant Professor, Department of Anesthesia, University of North Carolina, Chapel Hill
2008-2010	Melissa L. Wagner Schuman, MD, PhD. Cincinnati Children's Hospital Resident, Pediatric Residency Training
2005-2011	Daniel Roberson, PhD OD. Optometry school, NECO
2009-2013	Scott Greenwald Post-doc Harvard Medical School
2008-2015	Andy Salzwedel Post-doc University of North Carolina, Chapel Hill
2009-2015	Candice Davidoff, Senior Consultant, The Spur Group, Redmond, WA
2011-2015	Brian Schmidt Post-doc University of California, Berkeley
2016-	Sara Patterson
2017-	Anna-Lisa Doebley (MSTP)

Masters students

1994-1996	Paula Winans Schmit (MS)
2002-2003	Jeffrey Bojar, (MS)
1996-1997	Jenny Saskowski (MS)
2005-2005	Kelly Chmielewski (MS)

Ophthalmology Residents

2017-	Marcela Estrada, MD

UNIVERSITY COMMITTEES

Department of Ophthalmology

2009-	Appointments and Promotions Committee
2012-	Mentoring Committee

PATENTS

Awarded 1994	Patient video system for medical imaging equipment, E. A. DeYoe and J. Neitz.
Awarded 1995	Camouflage material for reducing visual detection by deer and other dichromatic animals, J. Neitz, D. Anderson, L. Johnson, and G. Hageman.
Awarded 1998	A method for diagnosing cone photoreceptor based vision disorders, M. Neitz and J. Neitz
Awarded 2015	Method and apparatus for limiting the growth of eye length
Pending	Myopia Safe Video Displays UW Ref. No. 45521. 02WO2
Pending	Reagents and methods for modulating cone photoreceptor activity, UW,
Pending	Method for treating cone photoreceptor disorders using virally mediated gene transfer
Pending	Compositions and methods for enhanced gene expression in cone cells
Pending	Quantification of exon 3 skipping in L and M opsin genes [IP: 47171.01US1]

PUBLISHED COLOR VISION TESTS AND MANUALS

2001	Neitz, J., Summerfelt, P. and Neitz, M. *Neitz Test of Color Vision.* Western Psychological Services, Los Angeles, CA.
2001	Neitz, J. and Neitz, M. Manual for the Neitz Test of Color Vision. Los Angeles: Western Psychological Services.
2002	Neitz, J. & Bailey, J. E. *HRR Pseudoisochromatic Plates*, Fourth Edition. Richmond Products, Boca Raton, Florida. *[This test has been rated as the best single color vision test: 2006 The new Richmond HRR pseudoisochromatic test for colour vision is better than the Ishihara test Cole, Barry L; Lian, Ka-Yee; Lakkis, Carol1 Clinical & Experimental Optometry, 89, 73-80}*

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BOOK CHAPTERS AND INVITED PUBLICATIONS

(1983) Jacobs, G. H., McCourt, M. E., & Neitz, J. Development of color vision mechanism in the ground squirrel. In J. D. Mollon & L. T. Sharpe (Eds.), *Color Vision Physiology and Psychophysics* (pp. 253-260). London: Academic Press.

(1994) Neitz, J., & Neitz, M. Color Vision Defects. In A. S. Wright & B. Jay (Eds.), *Molecular Genetics of Inherited Eye Disorders.* Chur: Harwood Academic Publishers.

(1998) Neitz, M. and Neitz, J. Molecular genetics and the biological basis of color vision. In W. Backhaus, R. Kleigl, and J.S. Werner (Eds.) *Color Vision - Perspectives from Different Disciplines*. Walter de Gruyter & Co.: Berlin - New York. p. 101-119.

(1999) Burke, J.M., Neitz, J., and Wong-Riley, M.T.T. The Visual System. In M.T.T. Wong-Riley (Ed.) *Neuroscience Secrets*. Hanley & Belfus, Inc.: Philadelphia, p. 69-98.

(2003) Neitz, M, & Neitz, J., Colour blindness. In: *Encyclopedia of the Human Genome*. Macmillan Publishers Ltd.: Houndmills, England.

(2003) McMahon, C., Neitz, J., and Neitz, M. Comparison of human and monkey pigment gene promoters to evaluate DNA sequences proposed to govern L:M cone ratios. In eds. Mollon, J.D., Pokorny, J., and Knoblauch, K., *Normal and Defective Colour Vision*, Oxford University Press.

(2003) Neitz, M., Bollinger, K., and Neitz, J. Middle-wavelength sensitive photopigment gene expression is absent in deuteranomalous color vision. In eds. Mollon, J.D., Pokorny, J., and Knoblauch, K., *Normal and Defective Colour Vision*, Oxford University Press.

(2004) Neitz, M, & Neitz, J. Molecular Genetics of Human Color Vision and Color Vision Defects. In: *The Visual Neurosciences*, ed. by L. M. Chalupa & J. S. Werner, MIT Press: Cambridge, MA.

(2008) Neitz, M. Green, D., Neitz, J. Color vision, acuity and adaptation. In Albert & Jacobiec's *Principles and Practice of Ophthalmology*, D.M. Alberts and J. Miller (Eds)

(2010) Neitz, M. and Neitz, J. Color vision defects. In *Ocular Disease: Mechanisms and Management*, L. Levine and D. Alberts (Eds)

PUBLICATIONS

1. Jacobs, G. H. and Neitz, J. (1984) Development of spectral mechanisms in the ground squirrel retina following lid opening. ***Experimental Brain Research***, **55**, 507-514.
2. Jacobs, G. H. and Neitz, J. (1984) ERG indices of color vision variations in monkeys. ***Doc. Opthalmol. Proc. Series,*** **38**, 49-55.
3. Neitz, J. and Jacobs, G. H. (1984) Electroretinogram measurements of cone spectral sensitivity in dichromatic monkeys. ***Journal of the Optical Society of America A***, **1**, 1175-1180.
4. Jacobs, G. H. and Neitz, J. (1985) Color vision in monkeys: sex related differences suggest the mode of inheritance. ***Vision Research***, **25**, 141-143.
5. Jacobs, G. H., Neitz, J. and Crognale, M. (1985) Spectral sensitivity of ground squirrel cones measured with ERG flicker photometry. ***Journal of Comparative Physiology, A*** **156**, 503-509.
6. Anderson, D. H., Neitz, J., Saari, J. C., Kaska, D. D., Fenwick, J., Jacobs, G. H. and Fisher, S. K. (1986) Retinoid-binding proteins in cone-dominant retinas. ***Investigative Ophthalmology and Visual Science***, **27**, 1015-1026.
7. Jacobs, G. H. and Neitz, J. (1986) Spectral sensitivity of cat cones to rapid flicker. ***Experimental Brain Research***, **62**, 446-448.
8. Jacobs, G. H. and Neitz, J. (1986) Spectral mechanisms and color vision in the tree shrew (Tupaia belangeri). ***Vision Research***, **26**, 292-298.
9. Neitz, J. and Jacobs, G. H. (1986) Re-examination of spectral mechanisms in the rat (Rattus norvegicus). ***Journal of Comparative Psychology***, **100**, 21-29.
10. Neitz, J. and Jacobs, G. H. (1986) Polymorphism of the long-wavelength cone in normal human color vision. ***Nature***, **323**, 623-625.

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12. Di, S., Neitz, J. and Jacobs, G. H. (1987) Early color deprivation and subsequent color vision in a dichromatic monkey. ***Vision Research***, **27**, 2009-2013.
13. Jacobs, G. H. and Neitz, J. (1987) Inheritance of color vision in a New World monkey (Saimiri sciureus). ***Proceedings of the National Academy of Sciences USA***, **84**, 2545-2549.
14. Jacobs, G. H. and Neitz, J. (1987) Polymorphism of the middle wavelength cone in two species of South American monkey: Cebus apella and Callicebus moloch. ***Vision Research,*** **27**, 1263-1268.
15. Jacobs, G. H., Neitz, J. and Crognale, M. (1987) Color vision polymorphism and its photopigment basis in a Callitrichid monkey. ***Vision Research***, **27**, 2089-2100.
16. Anderson, D. H., Williams, D. S., Neitz, J., Fariss, R. N. and Fleisler, S. J. (1988) Tunicamycin-induced degeneration in cone photoreceptors. ***Visual Neuroscience***, **1**, 153-158.
17. Blakeslee, B., Jacobs, G. H. and Neitz, J. (1988) Spectral mechanisms in the tree squirrel retina. ***Journal of Comparative Physiology***, **162**, 773-780.
18. Jacobs, G. H. and Neitz, J. (1989) Cone monochromacy and a reversed Purkinje shift in the gerbil. ***Experientia***, **45**, 317-403.
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20. Neitz, J. and Jacobs, G. H. (1989) Polymorphism of cone pigments in color normals: evidence from color matching. In G. Verriest and B. Drum (Eds.), ***Colour Vision Deficiencies IX***. Dordrecht: Kluwer Academic Publishers.
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23. Neitz, J. and Jacobs, G. H. (1990) Polymorphism in normal human color vision and its mechanism. ***Vision Research***, **30**, 620-636.
24. Crognale, M., Jacobs, G. H. and Neitz, J. (1991) Flicker photometric measurements of short wavelength sensitive cones. In B. Drum (Eds.), ***Color Vision Deficiencies X***. Dordrecht: Kluwer Academic Publishers.
25. Jacobs, G. H. and Neitz, J. (1991) Deuteranope spectral sensitivity measured with ERG flicker photometry. In B. Drum (Eds.), ***Color Vision Deficiencies X***. Dordrecht: Kluwer Academic Publishers.
26. Jacobs, G. H., Neitz, J., Crognale, M. and Brammer, G. L. (1991) Spectral sensitivity of Vervet monkeys (Cerpitnicus athiops sabaeus) and the issue of Catarrhine trichromacy. ***American Journal of Primatology***, **23**, 185-195.
27. Jacobs, G. H., Neitz, J. and Deegan, J. (1991) Retinal receptors in rodents maximally sensitive to ultraviolet light. ***Nature***, **353**, 655-656.
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29. Neitz, M., Neitz, J. and Jacobs, G. H. (1991) Spectral tuning of pigments underlying red-green color vision. ***Science***, **252**, 971-974.
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34. Jacobs, G. H. and Neitz, J. (1993) Electrophysiological estimates of individual variation in the L/M cone ratio. In B. Drum (Eds.), ***Color Vision Deficiencies XI***. Dordrecht: Kluwer Academic Publishers.
35. Jacobs, G. H., Neitz, J. and Neitz, M. (1993) Genetic basis of polymorphism in the color vision of platyrrhine monkeys. ***Vision Research***, **33**, 269-274.
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38. Neitz, M. and Neitz, J. (1995) Numbers and ratios of visual pigment genes for normal red-green color vision. ***Science***, **267**, 1013-1016.
39. Neitz, M. and Neitz, J. (1995) Genetic basis of photopigment variations in human dichromats. ***Vision Research***, **35**, 2095-2103.
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46. Hagstrom, S. A., Neitz, J. and Neitz, M. (1997) Ratio of M/L pigment gene expression decreases with retinal eccentricity. In B. Drum (Eds.), ***Colour Vision Deficiencies XIII***. Dordrecht: Kluwer Academic Publishers.
47. Neitz, M. and Neitz, J. (1997) Variety of photopigment genes underlying red-green color vision. In B. Drum (Eds.), Colour ***Vision Deficiencies XIII***. Dordrecht: Kluwer Academic Publishers.
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49. Jacobs.G.H., Deegan II, J.F. and Neitz, J. (1998) Photopigment basis for dichromatic color vision in cows, goats, and sheep. ***Visual Neuroscience***, **15**, 581-584.
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51. Balding, S.D., Sjoberg, S.A., Neitz, J. and Neitz, M (1998) Pigment gene expression in potan color vision defects. ***Vision Research***, **38**, 3359-3364.
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53. Kainz, P.M., Neitz, J., and Neitz, M. (1998) Recent evolution of uniform trichromacy in a new world monkey. ***Vision Research***, **38**, 3315-3320.
54. Kainz, P.M., Neitz, M., and Neitz, J. (1998) Genetic detection of female carriers of protan defects. Vision Research, 38, 3365-3369.
55. Neitz, M., Kraft, T.W., and Neitz, J. (1998) Expression of L cone pigment gene subtypes in females. ***Vision Research***, **38**, 3221-3225.
56. Shevell, S. K., He, J.C., Kainz, P.M., Neitz, J. and Neitz, M. (1998) Relating color discrimination and photopigment genes in deutan observers. ***Vision Research***, **38**, 3371-3376.
57. Sjoberg, S.A., Neitz, M., Balding, S.D., and Neitz, J. (1998) L-cone pigment genes expressed in normal color vision. Vision Research, 38, 3213-3219.
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61. Anderson, D.H., Hageman, G.S., Mullins, R.F., Neitz, M., Neitz, J., Ozaki, S., Preissner, K.T., and Johnson, L.V. (1999) Vitronectin gene expression in the adult human retina. ***Investigative Ophthalmology & Visual Science***, **40**, 3305-15.
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63. Carroll, J., McMahon, C., Neitz, M., and Neitz, J. (2000) Flicker-photometric ERG estimates of L:M cone photoreceptor ratio in men with photopigment spectra derived from genetics. ***Journal of the Optical Society of America A***, **17**, 499-509.
64. Hagstrom, S.A., Neitz, M., and Neitz, J. (2000) Cone pigment gene expression in individual photoreceptors and the chromatic topography of the retina. ***Journal of the Optical Society of America A***, **17**, 527-537.
65. Neitz, M., and Neitz, J. (2000) Molecular genetics of color vision and color vision defects. ***Archives of Ophthalmology***. **118**, 691-700.
66. Neitz, J, Carroll, J., and Neitz, M. Color vision is almost reason enough for having eyes. ***Optics & Photonics News***. **12,** 26-33.
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68. Anderson, D.H., Ozaki, S., Nealon, M., Neitz, J., Mullins, R.F., Hageman, G.S., and Johnson, L.V. (2001) Local cellular sources of apolipoprotein E in the human retina and retinal pigmented epithelium: implications for the process of drusen formation. ***American Journal of Ophthalmology***. **131**, 767-781.
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72. Crognale, M.A., Nolan, J.B., Webster, M.A., Neitz, M., and Neitz, J. (2001) Color vision and genetics in a case of cone dysfunction syndrome. ***Color Research and Applications.*** **26**, S284-287.
73. Neitz, M., Balding, S., and Neitz, J. (2001) A new test for mass screening of school age children for red-green color vision defects. ***Color Research and Applications***. **26**, S239-249.
74. Seme, M.T., Summerfelt, P., Henry, M.M., Neitz, J. and Eells, J.T. (2001) Differential recovery of retinal function after mitochondrial inhibition by methanol intoxication. ***Investigative Ophthalmology and Visual Science***. **42**, 834-841.
75. Carroll, J. Neitz, M. and Neitz, J. (2002) Estimates of L:M cone ratio from ERG flicker photometry and genetics. ***Journal of Vision***, **2**, 531-542.
76. Neitz, J., Carroll, J., Yamauchi, Y., Neitz, M., and Williams, D.R. (2002) Color perception is mediated by a plastic neural mechanism that remains adjustable in adults. ***Neuron***, **35**, 783-792.
77. Bollinger, K., Neitz, M. and Neitz, J. (2004) Topographical cone photopigment gene expression in the most common form of red-green color blindness. ***Vision Research***, **44**, 135-145.
78. Carroll, J., Neitz, M., Hofer, H., Neitz, J. and Williams, D. R. (2004) Functional photoreceptor loss revealed with adaptive optics: An alternate cause of color blindness. ***Proceedings of the National Academy of Science, U.S.A***, **101**, 8461-8466.
79. McMahon, C. Neitz, J., & Neitz, M. (2004) Evaluating the human X-chromosome pigment gene promoter sequences as predictors of L:M cone ratio variation. ***Journal of Vision,*** **4**, 203-208.
80. Bailey, J.E., Neitz, M., Tait, D. and Neitz, J. (2004) Evaluation of an updated HRR color vision test. ***Visual Neuroscience***, **21**, 431-436.
81. Crognale, M.A., Fry, M., Highsmith, J., Haegerstrom-Portnoy, G., Neitz, J., Neitz, M. and Webster, M.A. (2004) Characterization of a novel form of X-linked incomplete achromatopsia. ***Visual Neuroscience***, **21**, 197-204.
82. Neitz, M., Carroll, J., Renner, A., Knau, H., Werner, J.S., and Neitz, J. (2004) Variety of genotypes in males diagnosed as dichromatic on a conventional clinical anomaloscope. ***Visual Neuroscience***, **21**, 205-216.
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Since, 1986 Maureen Neitz and I have dedicated ourselves to working out the details of what causes color vision deficiencies and working out the visual capacities of those affected. No one has done as much work in this area as we have.

After working out the details of what color blindness is, how it is distributed in the population and the biology of what causes it, we have applied our many discoveries by developing a series of new color vision testing instruments. This includes the Neitz test of color vision, The *HRR Pseudoisochromatic Plates*, Fourth Edition and a genetic test of color vision. The HRR 4th edition has been the most widely sold clinical test of color vision in the United States for many years and it is currently in its second printing.

Finally, we have worked out methods to cure colorblindness.

Below, I have grouped our various clinically and regulatory oriented publications so it is easier to understand our contributions in the different areas.

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